Panel 1 - Insights from Installations
City of Seattle LED Street Lighting Conversion

Presented by: Edward Smalley
Director, Municipal Solid-State Street Lighting Consortium
Seattle City Light | Government and Legislative Affairs
Program Background

- Seattle City Light, a utility publically owned by the citizens of the City of Seattle since 1905
- Superintendant: Jorge Carrasco
- Tenth largest public power utility in the US with 405,000 metered customers
  - 6,284,760 MW of generation from 7 hydroelectric plants
- Number of Streetlights in system: 84,000
- First Phase of conversion: 41,000 Residential Streetlights over 4 years - 20,000 Units installed to date
Program Background - continued

- Projected Budget: $24 million (Projected Cost:$18 million)
- Funding:
  - Utility funding | Customer billed
  - $1 million ARRA EECBG Grant in 2010
- Goals:
  - Reduce energy use by 40% - **Actual 48%+!**
  - Lower maintenance costs (only lens cleaning during fixture life, no relamping, longer life photoelectric cell)
  - Improve Customer Service (increased reliability of the fixture, fewer outages)
Program Background - continued

Street Lighting Types by Use pre LED conversion

- Arterial Cobra Head Lighting: 31,447 (37%)
- Residential Cobra Head Lighting: 40,783 (49%)
- Pedestrian and Special Lighting: 11,705 (14%)

84,000 Total Fixtures

Pilot Evaluations in 2011
Program Background - continued

Street Lighting Types by Use – End Conversion Year 2

- Arterial Cobra Head: 31,439 (38%)
- Residential Cobra Head: 22,763 (27%)
- Residential LED: 18,000 (21%)
- Pedestrian and Special: 11,726 (14%)

84,000 Total Fixtures
Program Background - continued

System Energy Usages – Pre Conversion

- Arterial Cobra Heads: 52,827,180 kWh (59%)
- Residential Cobra Head: 22,693,382 kWh (25%)
- Pedestrian and Special: 14,334,629 kWh (16%)

Totals: 89,855,191 kWh
Program Background - continued

System Energy Usages – Post Conversion Year 2

- Arterial Cobra Heads: 52,827,180 kWh (61%)
- Residential Cobra Head: 12,733,536 kWh (15%)
- Residential LED: 6,898,500 kWh (8%)
- Pedestrian and Special: 14,334,629 kWh (17%)

86,793,845 kWh

Seattle City Light
Methodology – Fixture Selection

1. Identify demonstrations sites
2. Establish a **Specification** by modifying MSSLC Model Spec to select luminaires for evaluation based on demonstrations sites application
3. Acquire approved samples for engineering evaluation
4. Perform field demonstrations and evaluations
5. Conduct community surveys
6. Establish a **Standard** with “Approved Products” list
7. Conduct Bid Process
Typical Site Parameters

- Typical cross-section: 32 foot
- Luminaire mounting height: 25’ to 30’
- Light pole spacing: 150 feet
- Tree Conflicts: Seattle…
Luminaire Evaluation Process

- Internet Research & Phone Calls
- Manufacture Questionnaire
- Photometric performance
- “Made in America” status
- Manufacturers’ production capabilities
- Manufacturers’ Specification
- LM 79 & LM 80 Reports
- Pricing
Photometric Analysis

Computer Simulation

Based on the IES RP-8-00, Table 2

(American National Standard Practice for Roadway Lighting)

- Average maintained illuminance values.
  - 0.4 foot candles (Seattle 0.7 foot-candles)
- Uniformity ratios (average/minimum).
  - 6:1 with a minimum of 0.2 foot-candles allowed
Field Evaluation

Photometrics

**Before (HPS)**
- Illuminance levels of existing HPS system exceeded RP-8-00 minimums
- Uniformity for HPS did not meet RP-8-00

**After (LED)**
- Illuminance levels exceeded RP-8-00 minimums
- Illuminance levels of the LED fixtures exceeded HPS system levels
- Uniformity for LED improved over HPS
Community Outreach

- Pilots in Specific Neighborhoods representing demographics of Seattle
- Questionnaire to Every Household within pilot area, on web sites, and through news media
- Noted Major concerns and adjusted fixture selection for subsequent pilots
Financial Analysis

Base luminaire → 100 W HPS Cobra Head (138W mean)
- Annual fixture failure rate – 6%
- Annual lamp failure rate – 25% (effectively)
- 30,000 hour rated lamp
- Maintenance cycle 4 years (17,520 relamp cycle)

Comparison Luminaires → 70 Watt LED (total system)
- Annual failure rate – 1% (15% over 15 years)
- Annual lamp failure rate – n/a
- 65,700 hour to L85 (may not be TM-21 compliant)
- Maintenance cycle 7 years - cleaning

Life Cycle - 15 years (assumed)
Energy Rate - $0.053/kWh
Rebate - $0.23/kWh saved
Financial Analysis – Fixture Cost Trend

Bulk Purchase of 2500 or more units

- Fall 2009 - $369
- Spring 2010 - $289
- Fall 2011 - $239
Financial Analysis

<table>
<thead>
<tr>
<th># of Fixtures Installed</th>
<th>41,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implementation Period (years)</td>
<td>4</td>
</tr>
<tr>
<td>Analysis Period</td>
<td>15</td>
</tr>
<tr>
<td>Simple Payback (years)</td>
<td>7.6</td>
</tr>
<tr>
<td>15-Year Unlevered IRR</td>
<td>17.88%</td>
</tr>
<tr>
<td>15-Year Unlevered NPV ($)</td>
<td>$10,818,239</td>
</tr>
<tr>
<td>15-Year Capital Expenditure ($)</td>
<td>$18,232,359</td>
</tr>
<tr>
<td>15-Year Cap Ex $/kWh Saved</td>
<td>$0.1023</td>
</tr>
<tr>
<td>15-Year Cap Ex $/ton CO2e Saved</td>
<td>$174.4600</td>
</tr>
</tbody>
</table>
## Financial Analysis

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Annual kWh Savings</strong></td>
<td>13,199,130</td>
</tr>
<tr>
<td><strong>Annual Energy Cost Savings ($)</strong></td>
<td>$ 857,943</td>
</tr>
<tr>
<td><strong>Annual GHG Savings (tCO₂e)</strong></td>
<td>7,741</td>
</tr>
<tr>
<td><strong>Old Baseline Annual kWh Use</strong></td>
<td>25,769,730</td>
</tr>
<tr>
<td><strong>Old Baseline Annual Energy Cost ($)</strong></td>
<td>$ 1,675,032</td>
</tr>
<tr>
<td><strong>Old Baseline Annual GHGs (tCO₂e)</strong></td>
<td>15,114</td>
</tr>
<tr>
<td><strong>New Baseline Annual kWh Use</strong></td>
<td>12,570,600</td>
</tr>
<tr>
<td><strong>New Baseline Annual Energy Cost ($)</strong></td>
<td>$ 817,089</td>
</tr>
<tr>
<td><strong>New Baseline Annual GHGs (tCO₂e)</strong></td>
<td>7,373</td>
</tr>
</tbody>
</table>
# Financial Analysis – Savings Summary

<table>
<thead>
<tr>
<th>Residentail LED Installations</th>
<th>Units Converted</th>
<th>Savings Per LED</th>
<th>Monthly Savings</th>
<th>Annual Savings at end of period</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010 Installations</td>
<td>6000</td>
<td>$ 4.90</td>
<td>$ 29,400.00</td>
<td>$ 352,800.00</td>
</tr>
<tr>
<td>2011 Installations</td>
<td>12000</td>
<td>$ 4.90</td>
<td>$ 58,800.00</td>
<td>$ 705,600.00</td>
</tr>
<tr>
<td>2012 Installations</td>
<td>12000</td>
<td>$ 4.90</td>
<td>$ 58,800.00</td>
<td>$ 705,600.00</td>
</tr>
<tr>
<td>2013 Installations</td>
<td>11000</td>
<td>$ 4.90</td>
<td>$ 53,900.00</td>
<td>$ 646,800.00</td>
</tr>
<tr>
<td>2014 Installations</td>
<td>0</td>
<td>$ 4.90</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

All Residential Streets Installed: 41000  $ 200,900.00  $ 2,410,800.00
Annual System Management & Cleaning Costs $ (520,000.00)

Total Projected Savings at end of 2014: $ 1,890,800.00
Challenges

- Community Acceptance
  - Quality of Light – Selecting best color temperature
  - Light Distribution
- Lack of Standards – No one had ever done this before…(many current standards are now in place)
- Historical Design Practices – LLF, fixed drive currents, constant lumen maintenance, etc.
Lessons from the Field

Total Number Installed: ~ 20,000

- Failed units: 77 units (0.3% of total installed)
  - Failed out of the box: ~ >65
  - Failed in service: ~ <12
- Most common failure
  - Poor workmanship (i.e., faulty wiring, stripped screws, broken housing, etc.)
Lessons from the Field

Catastrophic Failure

- Failure Cause: Surge
- Failed Component: SPD
Lessons from the Field

- Manufacturer A - 37 Failed Units
  - Out of the Box: 35
  - In Field: 2

- Manufacturer B – 40 Failed Units
  - Out of the Box: 38
  - In Field: 2

- Other good pictures
Lessons from the Field
Weather Effects: Snow and Ice…Seattle Ice-Rain
Lessons from the Field

Weather Effects: No noticeable change at night
Lessons from the Field

Customer Complaints – 350 (1.67% of total installed)

- Color quality: < 5%
- Light trespass: 70%
  - Too much light in window
  - Not enough in yard
- Visibility: < 10%
  - Glare
  - Driver Awareness
- Remody
  - Shields
  - Lower drive current
LED Next Steps

- Adopt MSSLC Model Specification for LED Roadway Luminaires
- 2012
  - Purchase 12,000 units using adopted spec
  - West Seattle Freeway – Bridge Demonstration
    - (SCL | SDOT | Consortium | PNNL Partnership)
  - NEEA Acuity Study
  - Adaptive controls studies
New Technology Goals

• Remote Monitoring
  – Real-time metered power usage for each light
  – Immediate notification of streetlight malfunctioning
  – Quicker response time for repair

• Adaptive Controls
  – Ability to dim or brighten streetlights to meet vehicular and pedestrian demands
  – Set scenes for events and time of day
  – 20%+ Additional energy savings
Why LED Street Lighting for Seattle?

LED street lighting has proven to be a significantly better light source in terms of expected maintenance, energy efficiency, and quality of light.
Thank You…! Questions?

Edward Smalley
Edward.smalley@seattle.gov